

TMM015- Technical Mathematics II Guidelines (Draft- January 2020)

Typical Range: 3-4 Semester Hours

A course in Technical Mathematics specializes in the application of mathematics to the engineering technologies. The course emphasizes critical thinking by placing students in problem-solving situations and supporting students as they learn to make decisions, carry out plans, and judge results. Students encounter contextualized situations where concepts and skills associated with measurement, algebra, geometry, trigonometry, and vectors are the pertinent tools. The course highlights the supporting algebraic and analytical skills.

Rather than an Algebra course supplemented with applications, Technical Mathematics (TMM015) is intended to follow the spirit of a Quantitative Reasoning course. Instead of lectures presenting skills and procedures followed by practice activities, we hope this course will place students in situations where the mathematics become the tools for investigation. Applications should be the foundation of a collaborative experience, where groups of students make decisions, choose tools, follow plans, draw conclusions, and explain their reasoning.

To qualify for TMM015 (Technical Mathematics II), a course must achieve all of the following essential learning outcomes listed in this document (marked with an asterisk). The Sample Tasks illustrate the level of student engagement motivating this course.

1. Basic Elementary Functions: Successful Technical Mathematics students recognize basic function forms, algebraically and graphically, and can predict general behavior from this classification. Students can produce graphs of basic functions and provide descriptions of their behavior. Finally, students can develop and present this analysis as they deem useful.

The successful Technical Mathematics student can:

- 1a.** analyze basic polynomial functions. From a factored form, students identify zeros, multiplicities, locate and classify corresponding graph intercepts. From the graph or factorization, students discern locations of possible local maximums and minimums. Students produce graphs of polynomials given in factored form and describe the connection between zeros, factors, and intercepts. By examining the factored form, students can predict polynomial end-behavior. *
- 1b.** analyze basic rational functions. From a factored form, students identify zeros, poles, multiplicities, locate and classify corresponding graph intercepts and vertical asymptotes. From the graph or factorization, students discern locations of possible local maximums and minimums. Students produce graphs of rational functions given in factored form and describe the connection between zeros, factors, and intercepts and asymptotes. By examining the factored form, students can predict polynomial end-behavior and represent this graphically. *
- 1c.** analyze basic exponential functions. Students recognize basic exponential forms from formulas and graphs. Students explain general function properties and behavior and produce graphs from these. *

- 1d.** analyze basic logarithmic functions. Students recognize basic logarithmic forms from formulas and graphs. Students explain general function properties and behavior and produce graphs from these. *
- 1e.** analyze basic roots and radical functions. Students describe general function properties and behavior and produce graphs from these. *
- 1f.** analyze basic trigonometric functions. Students are fluent with the properties and behavior of sine, cosine, and tangent. Students identify zeros and their corresponding intercepts as well as asymptotes. Students provide exact values when appropriate and otherwise provide estimations. *

2. Algebraic Properties: Successful Technical Mathematics students apply basic algebraic properties of function types to produce equivalent forms appropriate for the current question or investigation.

The successful Technical Mathematics student can:

- 2a.** apply the distributive property effectively. Students decide when to factor or expand expressions to support a particular goal or enhance communication. Students identify common factors and construct equivalent products when seeking zeros. *
- 2b.** recognize algebraic structure. Students view expressions from the details of individual components to the patterns in which those components are suspended. Students attend to the broad algebraic structure before addressing details. *
- 2c.** students translate function characteristics and attributes to the reciprocal. *
- 2d.** manipulate exponents. Students condense, combine, and expand exponential expressions. *
- 2e.** manipulate logarithms. Students condense, combine, and expand logarithmic expressions. Students convert exponential-logarithmic compositions. *
- 2f.** manipulate radicals. Students condense, combine, and expand radical expressions. Students swap radical expressions for exponential expressions and vice-versa. *
- 2g.** utilize trigonometric identities. Students can use basic trigonometric identities to construct equivalent expressions. *
- 2h.** use algebraic properties in their analysis. Students make decisions on which algebraic properties to apply toward a goal and judge their progress. Students add, subtract, multiply, and divide functions. *

3. Rate of Change: Successful Technical Mathematics students communicate effectively about situational rates as well as rates-of-change encoded within functions.

The successful Technical Mathematics student can:

- 3a.** calculate rates of change over intervals. Students calculate rate-of-change and interpret. *
- 3b.** linearize a function around a point. Students plot tangent lines to graphs of functions and create linear functions that approximate the original function. *
- 3c.** see rate-of-change as a function. Students sketch approximate graphs for rate-of-change of a function. Use these to describe function behavior. *

4. Composition: Successful Technical Mathematics students are comfortable with the operations of functions, especially composition.

The successful Technical Mathematics student can:

- 4a.** compose functions. Students compose functions algebraically. Students can identify component functions from a given composition. Students can establish domains and ranges of compositions. *
- 4b.** view composition as an operation. Students view the identity function as the identity element in composition. Students can construct inverse functions and produce the identity function via composition. *
- 4c.** express linear composition graphically. Students interpret linear compositions in terms of graphical transformations. Students encapsulate graphical transformations algebraically. *

5. Analytical Geometry: Successful Technical Mathematics students are comfortable with various descriptions and interpretations of curves, especially ellipses.

The successful Technical Mathematics student can:

- 5a.** connect Cartesian equations and graphs of ellipses. Students can plot ellipses from equations. Students can create equations from plotted ellipses. *
- 5b.** parameterize ellipses. Students parameterize ellipses with sine and cosine. Students alter the trigonometric argument to change the parameterization without changing the curve. *
- 5c.** parameterize lines. Students create multiple parameterizations for the same line. *
- 5d.** interpret pieces of graphs as implicitly defined functions. Students can select domains and ranges to view a curve section as a graph of a function. Students can use an equation to evaluate a function defined implicitly. *